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A new species of *Rivula* Guenée (Lepidoptera, Noctuidae) from southeastern United States

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Abstract

Rivula stepheni **sp. n.** (Noctuidae, Rivulinae) is described from material collected in North Carolina and Louisiana. Illustrations of genitalia and adults of *Rivula* found in the United States are provided. The generic placement within the Noctuoidea is discussed.

Keywords

Rivula, *Oxycilla, Macrochilo*, North Carolina, Louisiana, Florida

Introduction

The genus *Rivula* Guenée currently is represented in the United States by two species. *Rivula pusilla* Möschler, 1890 (Fig. 1) is found in Florida and Texas (Heppner 2003). *Rivula propinquinalis* Guenée, 1854 (Fig. 2) is distributed throughout eastern North America from southern Canada southward to Florida and Texas and westward in the north to British Columbia and Washington. In North Carolina it is found from the Appalachian Mountains to the Atlantic coast.

During 1995 I collected a single specimen of what appeared to be an undescribed species of *Rivula*. In subsequent years additional specimens were collected occasionally. Eventually, enough specimens were collected to access its variation and describe the species.

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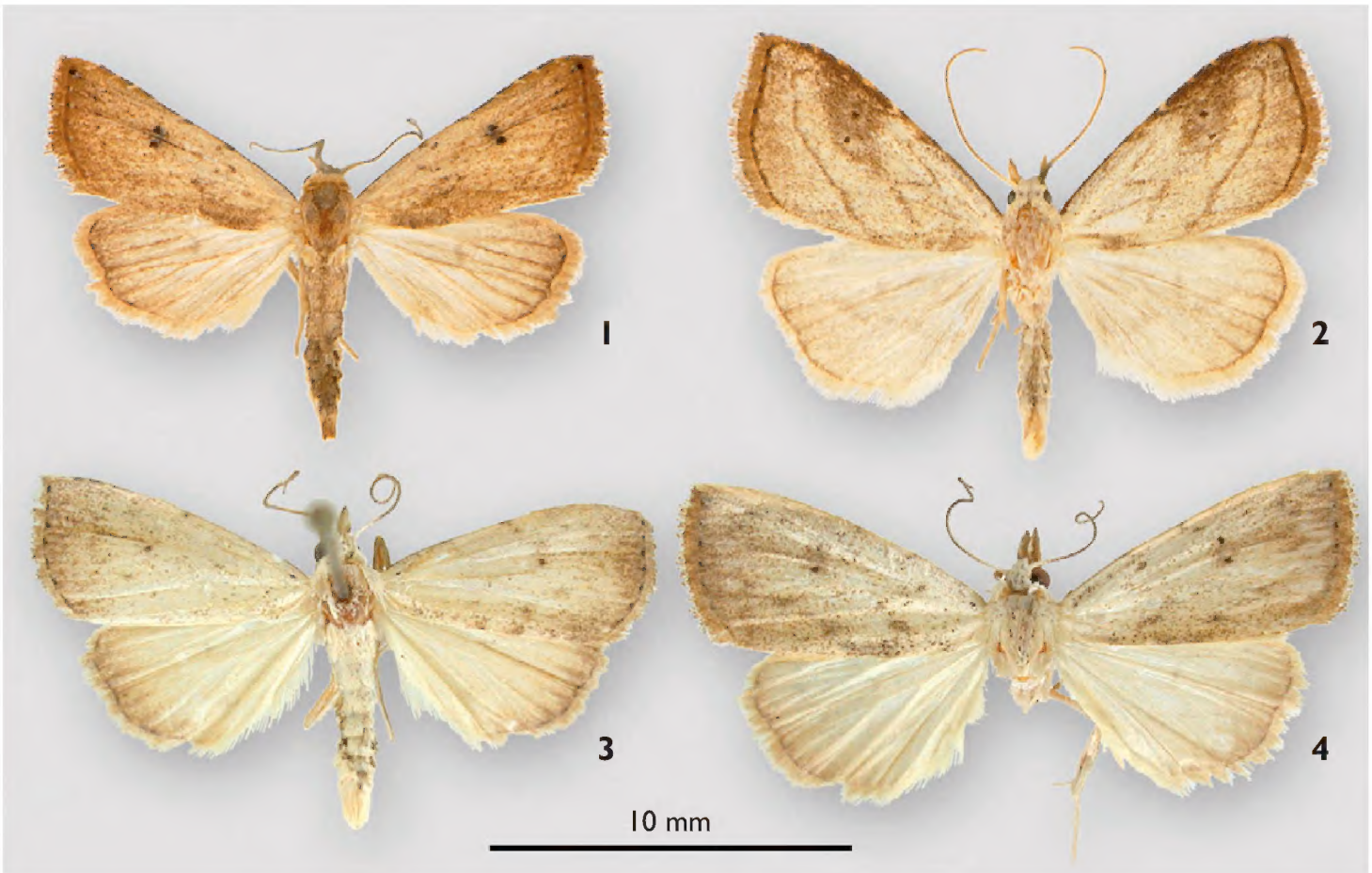

Figures 1-4. Adult *Rivula.* **1.** *Rivula pusilla* Möschler. 1.4 mi WSW Anthony, Marion Co., Florida, 2 Jan. 2006, Terhune Dickel. **2.** *Rivula propinqualis* Guenée. Edmundston, New Brunswick, 8 Sept 1987, Henry Hensel. **3.** *Rivula stepheni* Sullivan. Holotype. Macpherson Creek, Ft. Bragg, Cumberland Co., N.C., 20 June 2001. J. Bolling Sullivan. **4.** *Rivula stepheni* Sullivan. Croatan National Forest Road 3046, Craven Co., N.C., 7 April 1998, J. Bolling Sullivan.

Materials and methods

Repository abbreviations

BMNH Natural History Museum, London, UK

CNC Canadian National Collection of Insects, Arachnids, and Nematodes, Ottawa, Ontario, Canada

USNM National Museum of Natural History, Washington, District of Columbia, USA

JBS J. Bolling Sullivan, Beaufort, North Carolina, USA

VAB Vernon A. Brou, Jr., Abita Springs, Louisiana, USA

Specimens were examined from the USNM and pictures were sent to various active collectors in southeastern United States to determine if they had collected the new species. Genitalia were prepared by digestion in 10 % potassium hydroxide, dissected in water, stained with Eosin or chlorasol, and photographed with a Nikon Coolpix Camera. Legs from recently collected specimens were sent to Paul Hebert at the University of Guelph for barcode (CO1) analyses (sequencing of 658 base pairs of mitochondrial DNA from the 5' region of the gene coding for cytochrome oxidase subunit 1) (Ratnasingham and Hebert 2007).

***Rivula stepheni* Sullivan, sp. n.**
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Figs. 3-6, 11

Type locality. MacPherson Creek, Ft. Bragg, Cumberland County, North Carolina, USA.

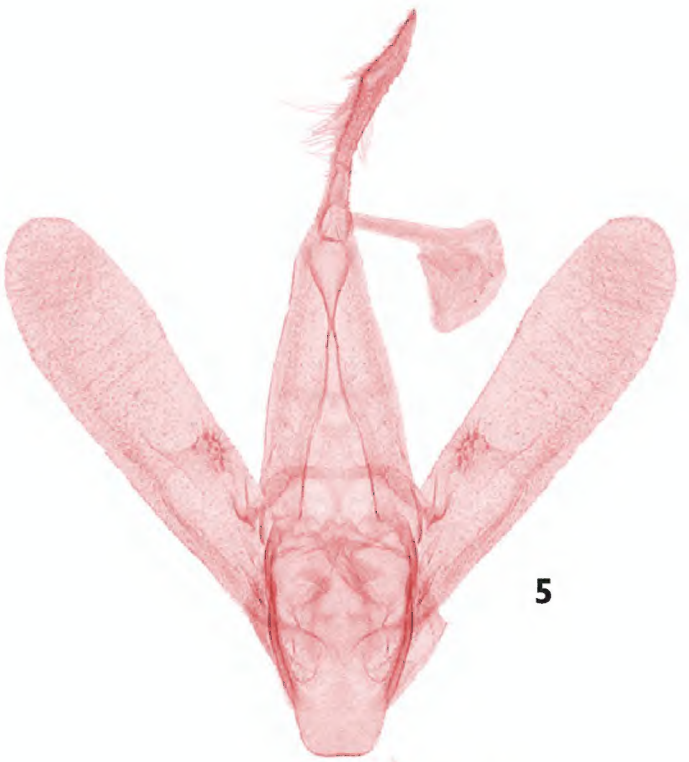
Type material. Holotype, male: USA, North Carolina: Cumberland Co., Ft. Bragg, MacPherson Creek, 20 Jun 2001, J. B. Sullivan (USNM). **Paratypes:** 29 ♂, 3 ♀: USA, **North Carolina:** Onslow Co., Camp LeJune, Verona Loop, 25 Jul1995 (♂); Craven Co., Croatan National Forest Rd. 147, 22.Apr.1996 (♂); Croatan National Forest Rd. 3046, Craven Co., 7.Apr.1998 (♂); Craven Co., Croatan National Forest Rd. 169, 16 Aug 1999 (♂); Cumberland Co., Ft. Bragg, MacPherson Creek, 21 Jun 2001 (♂); Craven Co., Havelock, off Sunset Drive, 31 Aug 2005 (♀) and 27 Sep 2005 (♂); Jones Co., Croatan National Forest, Haywood Landing, 24 Jun 2006 (♂); Craven Co., Croatan National Forest Rd. 3046, 20 Jun 2008 (2 m), all collected by J. B. Sullivan (BMNH, USNM, JBS). **Louisiana:** St. John the Baptist Parish, Edgard, 4 Sep 1975 (♂); 4.2 mi NE of Abita, 25 Oct 1984 (♂), 16 Sep 1986 (♂), 8 Oct 1989 (♂), 29 Aug 1992 (♂), 24 Sep 1994 (♂), 25 Sep 1994 (♂), 30 Sep 1994 (♂), 3 Oct 1994 (♂), 16 Oct 1994 (♂), 29 Oct 1994 (♂), 26 Sep 1995 (♂), 4 Oct 1996 (♂), 10 Oct 1996 (♂), 11 Oct 1996 (♂), 29 Oct 1997 (♂), 6 Oct 1997 (♂), 26 Oct 1998 (♂), 20 Sep 2002 (♂), 23 Dec 2002 (♀), 15 Jun 2005 (♂); West Feliciana Parish, Weyanoke, 8 Sep 1980 (♀), all collected by V. A. Brou, Jr. (CNC, VAB).

Other material examined. One additional specimen was examined from pictures supplied by Hugo L. Kons, Jr.: Florida, Gadsden Co., south side of Dolan Road, 0.1 miles W. of Hwy. 269, 23 May 1999, UV light trap, Hugo L. Kons, Jr. and Robert J. Borth.

Etymology. This species is named for Stephen A. Hall of the North Carolina Natural Heritage Program, whose tireless work to preserve natural habitats in North Carolina and to describe the natural communities in those habitats has greatly enriched the people of North Carolina.

Diagnosis. *Rivula stepheni* is a plain, ivory-colored species with scattered black markings but easily distinguished from other species with which it might be confused. *Rivula propinqualis* has a smooth diagonal postmedial line that approximately follows the line of the wing margin. In *R. stepheni* it is less well marked but clearly undulated. Additionally, there is a moderately large black spot (coastal plain specimens) or smudge (mountain specimens) along the forewing costa near the apex of the wing in *R. propinqualis* but two very small dots in *R. stepheni*. *Macrochilo louisiana* (Forbes) is superficially similar but has prominent labial palps. Wear quickly eliminates some of the scattered black markings in *R. stepheni*.

Description. Male (Figs. 3, 4): **Head –** antenna fasciculate, setae approximately length of shaft diameter; scape white; antenna scaled dorsally, white basally, becoming tan terminally; length of shaft 60 % of wing length; lower half of frons covered with straw to tan flattened scales; upper half of frons white medially, tan laterally, with narrow scales overlain with broader scales, all of which point anteriorly projecting over lower frons; eye without setae, slightly flattened toward thorax, scaling around eye straw to tan colored.; ocellus present; tongue normal; labial palp slightly porrect anteriorly,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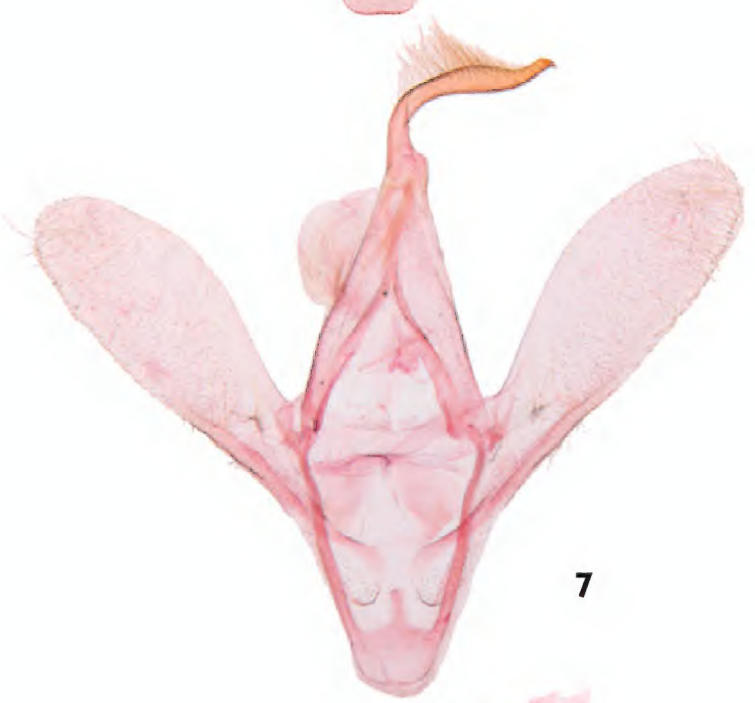
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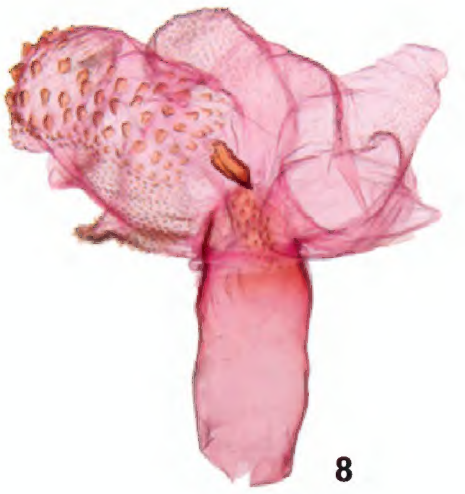
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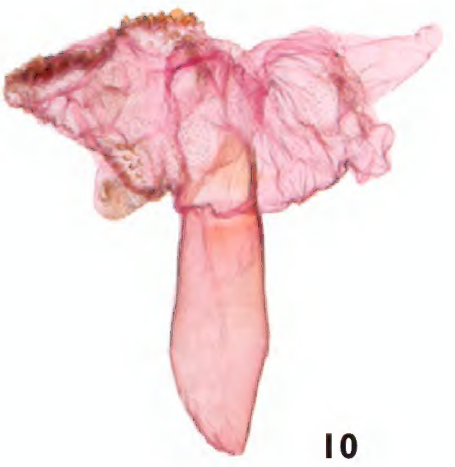
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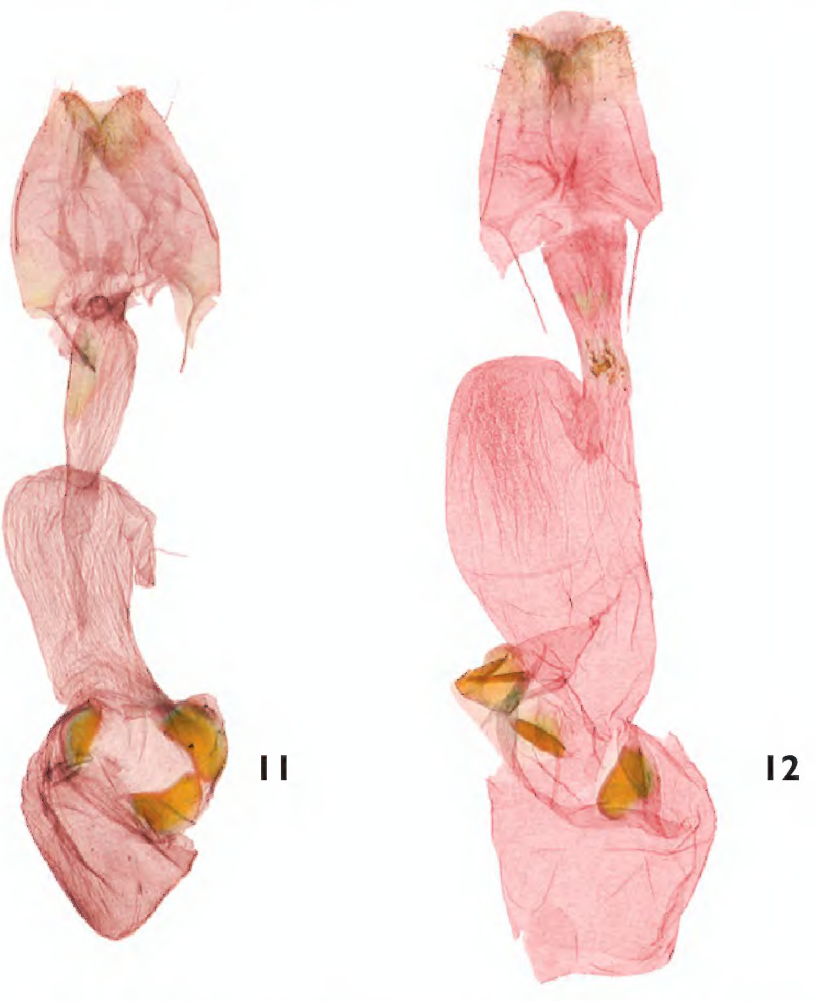
Figures 5-10. Male genitalia of *Rivula*. **5.** *Rivula stepheni* Sullivan. Valves. Craven Co., N. C. (JBS 2290). **6.** Aedeagus. Same data as valves. **7.** *Rivula propinqualis* Guenée. Valves. Edmundston, New Brunswick (CNC Noc. 14849). **8.** Aedeagus. Same data as valves. **9.** *Rivula pusilla* Möschler. Valves. Marion Co., Florida (CNC Noc 14848). **10.** Aedeagus. Same data as valves.

flattened dorsally; second segment 3 × longer than other two segments, broadly scaled dorsally and with large flattened scales ventrally, color tan on exterior, straw on interior; neck and collar covered with white scales. **Thorax** – with flattened scales overlaying pointed scales, with occasional darker scales intermixed; tegulae scales and coloration similar to remainder of thorax; leg scales white and straw with darker scales scattered throughout; prothoracic femur with grey scaling dorsally. **Forewing** – length 8.2-10.2 mm; ground color ivory with darker tan scaling along margins; reniform spot visible as two black spots, upper one slightly closer to thorax; basal black spot between vein Sc and R1; wing margins with tan scaling, a spot formed at extremity of each major vein; cross lines visible but often very diffuse. **Hindwing** – similar to forewing but without black spots. Underside similar to upperside but may be darker and without reniform or basal spots; retinaculum on base of costa, neither bar-like nor well defined. **Abdomen** – scales blunt tipped, white with occasional dark scales scattered throughout, particularly posteriorly. **Male genitalia** (Figs. 5, 6) – valves symmetrical; uncus elongate, widest in middle, knife shaped, setae found over entire surface but longest dorsally; base of uncus forms a window at junction with tegumen; gnathos and socii absent; anal tube strongly sclerotized dorsally; tegumen arms broad, forming inverted "V;" vinculum U-shaped, narrower, articulating directly with base of tegumen without pleural sclerite; valva 1.62 mm long, unsclerotized, membranous, with a subbasal broad, rounded ampulla covered with pimple-like processes bearing setae; costa excavated at base; juxta lightly sclerotized and difficult to see; transitilla membraneous; aedeagus: length 0.41 mm, short, stout, with ductus entering at base; vesica with two principal diverticula;



Figures 11-12. Female genitalia of *Rivula*. **11.** *Rivula stepheni* Sullivan. Craven Co., N. C. (JBS 2212). **12.** *Rivula propinqualis* Guenée. Alleghany Co., N. C. (JBS 2210).

base with band of short tooth-like projections; two diverticula separated by a broad, sclerotized, thumb-like disc; larger evagination on left covered with sharpened, peg-like cornuti over entire surface but largest on dorsal side; right diverticulum slightly scobinate. **Female** – similar to male except antennal setae sparse. **Female genitalia** (Fig. 11) – anal papillae with pimples bearing setae on inner surface; outer surface with long sparsely placed setae; each papilla triangular with blunt tip; posterior apophyses slightly longer than anterior ones, slender, with slightly rounded tips; ostium membranous, ductus bursae lightly sclerotized and striated, moderately thickened; corpus bursae with accessory bursa posteriorly on right side; posterior half of corpus bursae cylindrical, 2-3 × as broad as ductus bursae and slightly striated; anterior half of corpus bursae forming heart-shaped chamber containing three embedded plate-like signa; two signa situated posterior to third signum, all well sclerotized; total length of female genitalia 3.93 mm.

Distribution and biology. Initially thought to be limited in distribution to eastern North Carolina, a picture of an unknown moth collected in Gadsden County, Florida by Hugo Kons, Jr. and Robert Borth was provided and is *Rivula stepheni*. All North Carolina specimens were found in mesic mixed pine and hardwood forests near small streams with cane (*Arundinaria* spp.) growing nearby. The adjacent upland areas contain both hardwoods and loblolly pine (*Pinus taeda* L.) with American holly (*Ilex opaca* Ait.) and witch hazel (*Hamamelis virginiana* L.) in the understory. Typically, cabbage palmettos (*Sabal palmetto* (Walter) Lodd. ex Schult. & Schult. f.) are in the floodplain of the stream. Grasses and small sedges are common in the floodplain area and both *Rivula propinqualis* and *R. stepheni* have been found in the same trap. The Florida specimen was collected on May 23, 1999 in Gadsden County in essentially identical habitat (Hugo Kons, Jr., personal communication). North Carolina specimens have been captured from early April (Fig. 4) through September indicating that the species bred continuously in the area (likely representing three or four broods). Summer captures are most common and spring specimens are approximately 20 % larger than individuals from subsequent broods (see Sullivan and Miller 2007).

Twenty two additional specimens were collected by Vernon A. Brou, Jr. in Louisiana, primarily at his home near Abita Springs. These specimens were collected during an extensive year round trapping program ongoing statewide for 40 years. They were taken in June (1), August (1), September (8), October (10), November (1), December (1) and each was a singleton capture in one of six traps operated each night. This would indicate that the species is not breeding at the trapping site but instead is wandering into the trapping area from some presumed nearby site. *Rivula pusilla* is known to migrate late in the year into the Gainesville, Florida area in some years (Hugo Kons, Jr., personal communication) and the European *R. sericealis* is known to migrate within Europe and to Britain (Sparks et al. 2007; Wood et al. 2009). Captures in the Abita Springs area may derive from a similar wandering/migratory behavior in the fall and their infrequent occurrence would indicate that the species is limited in distribution in Louisiana as well as in Florida and North Carolina.

Reported host plants for species of *Rivula* are grasses and sedges. Larvae pupate in loose cocoons covered with debris (figured in Kitching and Rawlins 1999).

Discussion

The genus *Rivula* has a peculiar history. It has no known closely related genera (however, see *Zebeeba* Kirby in Speidel et al. 1996) and has been placed in the Rivulinae, Hypeninae, Hermininae and near the arctiids and lymantriids (Kitching 1984; Mitchell et al. 2005; Lafontaine and Fibiger 2006). The genus is characterized by unique larval characters, and in the adult by the rudimentary pockets of the tympanum (Richards 1933), and perhaps the microsculpturing of the proboscis (Speidel et al. 1996). None of the diagnostic characters is easy to score. Based on the hindwing venation (Forbes 1954), a fully scaled frons, and the simple, unsclerotized valves, *Rivula* is placed among the more primitive quadrifine noctuids (Lafontaine and Fibiger 2006).

Based on examination of the three North American species of *Rivula* (Figs. 1-4), the European *R. sericealis* (Scopoli), and Asian species treated by Holloway (2008), several characters may prove to be unique (probably in combination) for rivulines. In the forewing the reniform spot appears as two distinct dots. This is overlaid with black scaling in many *R. propinqualis* (Fig. 2) and *R. sericealis*. These twinned dots seem to be present in Bornean species as well (Holloway 2008). In *Oxycilla* Grote (Boletobiinae), a possible sister group, twinned spots are visible in *O. mitographa* (Grote) and *O. ondo* (Barnes) but not in the other three species currently placed in the genus. Most *Macrochilo* Hübner (Herminiinae) species also show the twinned dots. In the male genitalia of *Rivula* (Figs. 5-10) the valves are not sclerotized, the clasper is usually limited to a small ampulla, and the aedeagus is short and straight but wide and large relative to the rest of the genital capsule. The vesica is moderately complex (a series of diverticula) and granulose, often with numerous peg-like cornuti. In the female bursae (Figs. 11-12) signa are present as three distinct plates in *R. propinqulis* and *R. stepheni* and as thin longitudinal plates in the Bornean species (Holloway 2008). The yellowish, straw-colored pattern of *R. sericealis* is repeated in *R. propinqualis*, some Bornean species and some neotropical species. Worn *R. stepheni* are almost white, but otherwise are similar to the *R. propinqualis* and *R. sericealis*. Other Bornean and New World species of *Rivula*, including our *R. pusilla* (Fig. 1), show another forewing pattern with a reddish ground color and light spotting. Examination of the CO1 sequences ('barcode fragment', 658 residues) reveals sequence differences of about 4-5 % between *R. propinqualis* , *R. stepheni* and *R. sericealis*. That branch of three species is somewhat more isolated from *R. pusilla* and several other neotropical species. Most neotropical species have not been dissected so their placement in *Rivula* must be considered provisional. Some 26 sequences of *R. propinqualis* from Ontario, Quebec, Maryland, Tenneessee, and North Carolina are heterogeneous with intraspecific differences of up to 2 %. However, these differences do not sort geographically nor do variations in the diverticula of the vesica in samples from North Carolina, New Brunswick, Ontario and British Columbia. The same can be said for seven sequences of CO1 from *R. pusilla* from Florida and Costa Rica and genitalia preparations from Florida, Dominica and Costa Rica. The type locality of *R. pusilla* is Puerto Rico. Interestingly, several unplaced neotropical species from Costa Rica, currently in the Scolecocampinae, another primitive

quadrifid noctuid group, bear a striking resemblance in maculation to *Rivula*. Larvae of both groups are thought to feed on grasses, fungi and decaying litter.

Acknowledgements

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